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Forestry Research West

Forest Service
U.S. Department of Agriculture

January, 1979

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Forestry Research West

Forest Service
U.S. Department of
Agriculture

January, 1979

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

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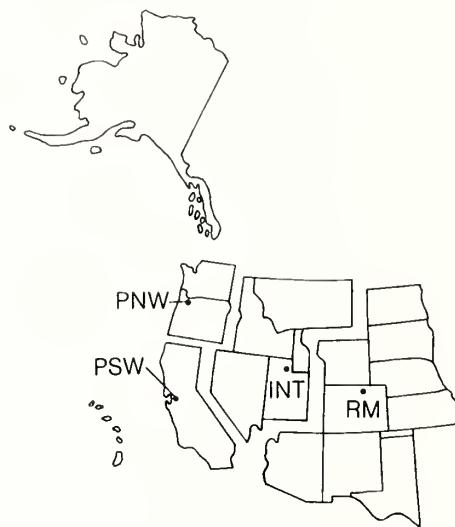
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Cover

Scattered woody debris, as shown in this ponderosa pine setting, provides important cover for small mammals. Studies have recently shown that these animals may play an important role in the growth and survival of coniferous forests by spreading the spores of mycorrhizal fungi. Read more about this research on page 1.

Small mammals traffic in truffles

The California red-backed vole eats only fungi and lichens.



New information about the food habits of small mammals indicates that they are the unheralded allies of foresters. Instead of being simply seed-and seedling-eating pests, they play a vital role in the health and survival of coniferous forests. They do this by eating truffles and traveling a lot, spreading the spores of mycorrhizal fungi as they go.

"Small mammals are important to forest regeneration and may be critical for the survival and growth of trees on some unfavorable sites," says Mycologist Jim Trappe of the Pacific Northwest Forest and Range Experiment Station in Corvallis, Oregon. Trappe has published extensively on the importance of mycorrhizal fungi to the growth and vigor of natural and planted seedlings. He is also the mycologist half of a unique scientific team which has made important discoveries about the relationship of truffles and small mammals in the forest ecosystem.

Scientists form team

As Trappe recalls it, the idea for the study grew out of one of those occasions when scientists from different disciplines meet for the first time, talk shop, bounce ideas around, and suddenly recognize an opportunity to collaborate on a problem that has puzzled both of them.

In this case, Trappe met Chris Maser, a wildlife biologist, on a field trip. Maser works for the Bureau of Land Management in La Grande, Oregon, and is one of the few people in the country conducting a broad spectrum census of small mammal populations. He told Trappe about finding a

truffle in the mouth of a Douglas squirrel he had shot. Trappe knew that small mammals dig up and eat truffles. But he didn't know how important truffles are in the diet of the animals or what happens to the fungal spores that are eaten. He wanted to find out. So did Maser. It dawned on both scientists that together they might be able to find some answers.

"Could you recognize truffles in stomach contents?" Maser asked. "Give me some and I'll see," said Trappe, one of the few people in the world with the ability to do this. With the aid of a microscope, Trappe found that he could recognize fungal spores in both stomach contents and feces. He could also tell whether the spores came from mycorrhizal fungi and whether they were from species which reproduce by truffles under ground or mushrooms above ground.

From this beginning in 1971 grew the first large scale study to identify fungal spores in the stomach contents and feces of small forest mammals. So far material from 29 species of shrews, pikas, rabbits, squirrels, gophers, mice, woodrats, and voles has been examined. The findings have documented food habits, settled long-standing questions about spore viability, and shed new light on ecological relationships between plants, fungi, and small mammals.

WHAT ARE MYCORRHIZAL FUNGI?

The term mycorrhiza means fungus-root. Mycorrhizae are formed when fungi grow among the outer cells of plant rootlets. The fungi assist plants in absorbing nutrients and water from the soil and often protect roots from disease. The plants provide fungi with photosynthetic products such as carbohydrates and vitamins. Mycorrhizal fungi cannot live without host plants. Very few green plants grow well, or even survive, without mycorrhizal fungi.

There are thousands of species of mycorrhizal fungi. Each has environmental requirements and has evolved to team up with particular plant species.

WHAT ARE TRUFFLES?

Truffles (including false truffles) are the reproductive bodies of certain species of mycorrhizal fungi which mature in the soil. They are fleshy structures, shaped like small potatoes, that contain spores capable of germinating to form mycorrhizae when they encounter plant rootlets. They are related to mushrooms but have evolved to a more specialized habit. By growing in the soil, they are more protected from frost and drying than mushrooms. At the same time, they require animals for spore dispersal whereas mushroom spores are carried by moving air.

Two questions answered

Early in the study the scientists answered two important questions: (1) are the fungal spores in truffles eaten by animals mature enough to germinate and (2) are the spores viable after passing through the digestive tract? The answer to both questions is



The truffle Tuber-gibbosum, native to west coast Douglas-fir forests.

Truffles resemble small potatoes.



"yes." In the laboratory, spores of truffles fed to study animals passed through digestive tracts, germinated, and formed mycorrhizae with the roots of seedlings.

Armed with this knowledge and mounting evidence of the importance of truffles in the animals' diet, Trappe and Maser took a new look at the role of small, truffle-eating mammals in forest ecosystems. They concluded that the animals were the unrecognized third partner in a mutual benefit association with plants and fungi. Just as plants and fungi evolved over thousands of years to depend on each other for nutrients, water, and protection, the small mammals grew to depend on truffles for some of their food and water. In return, the animals contribute to the welfare of the forest by transporting truffle spores from place to place. As they travel between established forest and clearcut, burned, or other deforested areas the animals drop their fecal pellets. When these are washed into the soil by rain the spores become available to form additional mycorrhizae with plant roots. "Transportation by small mammals is the only known dispersal method," says Trappe. "In fact, we may find that passage through an animal's digestive tract stimulates the spores to germinate."

Fungal spores found

Evidence of the importance of fungi in the diet has come from the digestive tracts of animals trapped or shot by Maser throughout the year in various parts of Oregon. Materials from additional animals have come from Alaska, Washington, California, British Columbia, Arizona, Colorado, Iowa, and Indiana, contributed by wildlife biologists who have heard about the study and want to share materials in exchange for information for their own studies.

Trappe and Maser have published information of interest to foresters about the food habits and behavior of these small mammals. For example, the Townsend chipmunk is one of the important carriers of fungal spores in western Oregon, because it travels relatively long distances from old-growth timber to forest clearcuts. Truffles made up 77 percent of the diet of study animals and were found in 93 percent of the individuals examined.

Another important truffle-carrier is the California red-backed vole. Its diet consists entirely of fungi and lichens. It eats no seeds. Truffles made up 74 percent of the stomach contents of 123 voles examined. This animal had been considered rare in western Oregon until the present study because it was seldom caught in traps. By placing traps along the animal's usual travel routes under rotten logs, instead of in grid fashion, Maser discovered that the animal is actually common.

Other heavy and consistent eaters of truffles include the yellow pine chipmunk, the Gapper red-backed vole, and the northern flying squirrel.

While some species are heavy and consistent truffle-eaters, other species eat truffles more sporadically. All species examined had eaten at least a trace of truffles. Most apparently nibble, eating one, then another species. Most rodents eat truffles when they are available but also eat a variety of other food, such as seeds and fruits in season.

Truffles attract by odor

Study results also indicate that small mammals—epicureans that they are—apparently prefer truffles even to mushrooms, another form of forest fungi. As truffles mature, they give off odors which attract the animals. Evidence that small mammals have a keen sense of smell comes from the fact that species of fungi that mycologists had thought were rare have turned up surprisingly often in the digestive tracts of study animals. Truffles, which mature slowly, are also available much longer than mushrooms, which push through the soil surface and last for only a few days.

Trappe and Maser have concluded that most small mammals are compatible with timber production and some are decidedly beneficial. It is true that some animals chew on the bark of young trees or eat a lot of tree seed, but these are not serious problems if a variety of other foods are available. They suggest several ways foresters can promote balance in the forest and be hospitable to small, truffle-eating mammals.

Habitat needs

Animals require habitat that fits their needs, including protective cover that permits them to travel safely between forest areas and openings. Edges are important. These are the transition zones where different plant communities or successional stages of vegetation come together. They provide travel cover and sources of food. Woody material, especially logs and snags, provides cover and sites for feeding and reproduction. Animals can make better use of woody debris that is scattered than debris concentrated in large piles.

Logs are of particular importance because they supply a variety of needs to whole communities of organisms, including small mammals. One probable reason the familiar "nursery" log provides a good environment for developing seedlings is that small mammals attracted to the log leave spores of mycorrhizal fungi—as well as fertilizer—around them, ready to form mycorrhizae with the roots of new seedlings. Logs which lie along land contours appear to be used more by small mammals than those which lie across contours.

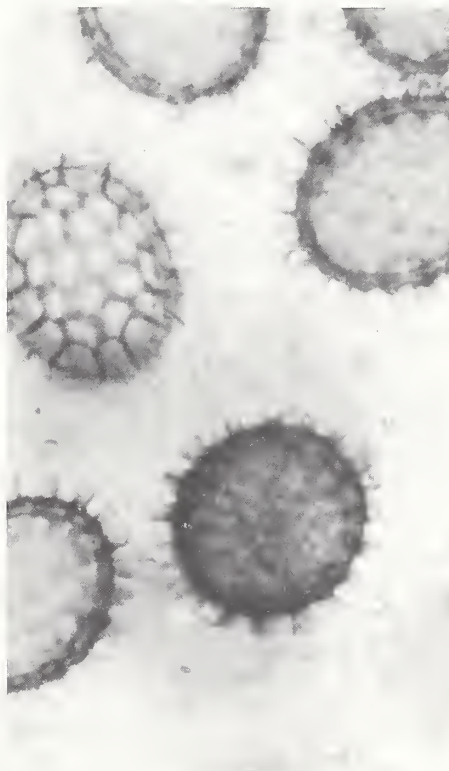
Although Trappe and Maser have done most of their work with Oregon animals, their approach—finding out exactly what animals eat and interpreting findings in terms of ecosystem functioning—is applicable to parts of the country where other animals, such as peckaries and armadillos, may be the principal truffle-eating and disseminating species.

Maser feels that studies like this one which cross disciplinary lines are needed if scientists are to give foresters the information they need to understand how forest ecosystems work. "Even in an era of specialization we have to realize that we are all dealing with the same limited land base," he says.



Mycorrhizae formed on the roots of a ponderosa pine seedling after inoculation with fecal pellets from a California red-backed vole. The vole had been fed truffles of Rhizopogon idahoensis in the laboratory.

Spores of a truffle found in the stomach of an Oregon vole, as seen through a microscope. Spores are actually about as big as the point of a pin.



Mystery solved

Occasionally research pays an unexpected, interdisciplinary bonus. In this study, information about what flying squirrels eat helped solve a mystery. The mystery was why the remains of flying squirrels had turned up in the feces of bobcats and coyotes collected by Maser during a previous study of their role as predators. Since the squirrels live in trees, and bobcats and coyotes cannot climb well enough to catch squirrels, the squirrels obviously spent some time on the ground. But, why? Was it just the dare-devil act of a few teenage squirrels? It may have been the temptation of truffles. Remains in squirrel digestive tracts indicated that they left their trees at night to dig in truffle patches, in spite of the danger from predators.

Publications

More detailed findings from the Trappe-Maser study are available in "Implications of Small Mammal Mycophagy to the Management of Western Coniferous Forests" by Chris Maser, James M. Trappe, and Douglas C. Ure, in Proceedings of the North American Wildlife Resources Conference 1978.

Two others papers are in press. They are "Fungal-Small Mammal Interrelationships with Emphasis on Oregon Coniferous Forests," by Chris Maser, James M. Trappe, and Ronald A. Nussbaum and "Ecto-mycorrhizal Fungi: Interactions of Mushrooms and Truffles with Beasts and Trees," by James M. Trappe and Chris Maser.

A review of knowledge about mycorrhizae, with emphasis on mycorrhizae function in ecosystems, is available in "Ecosystematic Functions of Mycorrhizae," by James M. Trappe and Robert D. Fogel, in "The Below-ground Ecosystem: A Synthesis of Plant-associated Processes," p. 205-214

All of these references are available from the Pacific Northwest Station.

—by Dorothy Bergstrom, Pacific Northwest Station

WESTFORNET aids wildland managers

Foresters working in backwoods regions of the Western U.S. no longer need to feel isolated from what's going on in forestry, thanks to the services of the Western Forestry Information Network or "WESTFORNET." This unique network offers an assortment of technical information services that can keep foresters and their co-workers up-to-date. WESTFORNET's *Monthly Alert*, for example, is a regular announcement of new books, research papers, technical reports, and other literature in forestry and in every other field that is a part of modern forest management. WESTFORNET service centers in Seattle, Berkeley, Ogden, and Fort Collins provide delivery of any of these materials to Forest Service offices in the Western U.S.

WESTFORNET customers interested in publications not included on the *Monthly Alert* can get the items they want through WESTFORNET's "general document delivery" service. WESTFORNET librarians and technical information specialists will do "literature searches," tracking down materials that may help solve a particular problem in wildland management or research. And, if little has been written on a subject, WESTFORNET may try to put customers in touch with specialists who are currently doing research in the customer's area of interest.

The Western Forestry Information Network—WESTFORNET—serves scientists and wildland managers in the western U.S.



All of these services have been available to Forest Service foresters and researchers in California, Hawaii, and the Pacific Northwest since 1975, under the old "PACFORNET" (Pacific Coast Forest Research Information Network) system. WESTFORNET replaced PACFORNET in May, 1978, and expanded service to 17 Western States. Forest Service employees in the West can use WESTFORNET, as can some cooperators. "People who have heard about PACFORNET are anxious to start using WESTFORNET," says Bob Hamre of the WESTFORNET-Fort Collins center. At WESTFORNET-Ogden, "business is booming," according to Liz Close. "We had people asking us to do literature searches even before we announced that we would be offering this service."

The Monthly Alert

The best-known and most widely used of the WESTFORNET services is the **Monthly Alert**, which is sent to some 6,600 readers each month, to notify them of what's been added to the collections of the WESTFORNET libraries. Each **Alert** runs about 15-20 pages, and advertises more than 200 documents, including reports presented at conferences, research papers, theses, impact statements, and legislative documents. The four regional editions of the **Alert** have about three-fourths of their content in common, with one-fourth of each edition left for items of strictly local interest, such as articles that the WESTFORNET-Seattle staff picks up from **Northwest Science**, or that WESTFORNET-Berkeley gets from such sources as **California Geology**.

Selections for the **Monthly Alert** are made on the basis of what the WESTFORNET staff knows about the programs and problems of WESTFORNET users. This means that the staff not only has to be familiar with current research and management programs throughout the West, but also has to keep an eye out for important new developments. The resulting **Monthly Alerts** are as diverse as their audience—entries in a typical **Alert** can range from air pollution to zoology. Items are selected from some 50 different sources, including catalogs, such as **Government Reports Announcements** and **Wildlife Review**, and from some 30 different journals, including **Science**, **Nature**, **Journal of Hydrology**, **Journal of Mammalogy**, **Forest Science**, and others. All **Alert** items are available from one or more of the WESTFORNET centers. Most are "loaner" copies, but sometimes there are publications that customers can keep.

The **Monthly Alert** is a good advertisement for the rest of the WESTFORNET services. Explains Frances Barney of WESTFORNET-Fort Collins, "A lot of people in our area have had very little library service in the past; the **Monthly Alert** gets them interested."

Some **Alert** items are much in demand. More than 100 people signed up to borrow a paperback, "Literature Review of Twenty-Three Selected Forest Birds of the Pacific Northwest," from WESTFORNET-Seattle. Other best sellers: a California paper on "Fuel Reduction Without Fire—Current Technology and Ecosystem Impact;" a 143-page book, "Modern and Classic Woodburning Stoves and the Grass Roots Energy Revival;" a report from the University of California's Water Resources Center, "Evaluation of Streamside Buffers for Protecting Aquatic Organisms;" and a University of Wyoming thesis, "Effects of Clearcutting on Water Discharge and Nutrient Loss, Bitterroot National Forest, Montana."

Citations for the items on each **Monthly Alert** are kept in a master catalog, or "data base." A pocket-sized version of this catalog is available on microfiche.

Cooperating libraries

Through the "general document delivery" service, the WESTFORNET staff will find and loan literature that people may hear about through sources other than the **Alert**. WESTFORNET-Berkeley, which is located at the Pacific Southwest Forest and Range Experiment Station, may borrow from the neighboring University of California, which has not only a huge main library but some 50 small, specialized branches on campus as well. WESTFORNET-Seattle is conveniently located in the Forest Resources Library at the University of Washington. "Almost 75 percent of the items that people ask for are available here on campus," says WESTFORNET-Seattle's Kay Kinkad.

Customers in the WESTFORNET-Ogden area, which is headquartered at the Inter-mountain Forest and Range Experiment Station, can borrow from the University of Idaho library at Moscow, or the Utah State University library in Logan. WESTFORNET-Fort Collins at the Rocky Mountain Station can borrow from the stacks at Colorado State University.



Terminals at each of the four service centers are WESTFORNET's link to computerized databases.

If an item isn't available locally, the WESTFORNET specialists can often get what they need from the National Agricultural Library in Beltsville, Maryland, which loans materials free of charge to fellow U.S. Department of Agriculture agencies. Or, they can borrow from other libraries—almost anywhere in the world—or can write directly to authors. Thelma Sameth at WESTFORNET-Seattle frequently writes to Sweden's Royal College of Forestry for their reports, and has also sent queries to authors in Australia, New Zealand, Thailand, Uganda, and Nigeria. Great Britain's National Lending Library has provided reports for WESTFORNET-Berkeley, as have authors in Germany and Norway.

Computerized searches

The "literature search service" is possible through WESTFORNET's links to computers that can rapidly scan thousands of citations, looking for just what the customer needs. Citations from such sources as **Forestry Abstracts**, **Biological Abstracts**, **Bibliography of Agriculture**, and **Dissertation Abstracts**, can be printed out at WESTFORNET offices at the rate of one full page of citations every 2 minutes. WESTFORNET has access to some 65 such specialized data bases, each containing thousands of titles and abstracts. These indexes are only a phone call away from WESTFORNET service centers.

Some searches, such as those in timber management or fire control, may be fairly routine. Others can challenge the WESTFORNET staff's ability to develop a "search strategy"—the step-by-step plan of attack designed to get the best citations in the least amount of time. Thelma Sameth, Seattle, recalls a search she did for a customer at Oregon Dunes National Recreation Area who wanted reports on dune ecology and, especially, "anything on European beach grass." Her search produced about 500 citations, ranging from "Vegetative Coastal Dunes. Growth Detection from Aerial Infrared Photography" from a journal of remote sensing, to an article on "Ecology of Soil Fauna of Mediterranean Desert Ecosystems in Egypt . . ." from *Review of Ecological and Biological Sciences*. WESTFORNET will deliver any or all of the documents that turn up in these searches.

Vince Aitro, WESTFORNET-Berkeley, has done searches on prescribed burning of sagebrush, management of native California oaks, and the life history of blunt-nosed and long-nosed leopard lizards. At Fort Collins, Larry VanDeusen has hunted up citations on hard-rock mining for the Forest Service's Rocky Mountain Regional Office in Denver, has found items on Barbary sheep for a Rocky Mountain Station researcher in Texas, and has come up with materials for foresters in South Dakota on how to restore streamside vegetation.

The requests for information on obscure subjects are treated with the same enthusiasm as the more mundane searches. In all cases, the WESTFORNET staff has been successful in coming up with materials. Colleagues of Frances Barney, WESTFORNET-Fort Collins, say that "if you give her the middle word of a title of a book, she'll know which book you mean, and will find it for you."

The average cost for the searches is \$5-\$6. WESTFORNET-Berkeley and Seattle have already done hundreds of searches, a feat made possible by the computerized data bases. "We couldn't possibly have helped this many people if we had to do each search by hand," says Vince Aitro, Berkeley.

Searches have to be done by hand if the customer wants literature that was published in the years before the computerized data bases were produced. According to Aitro, most of the automated indexes go back only as far as about 1970. "If we need anything earlier than that, we have to look it up ourselves, making a painstaking search through the indexes that aren't automated." In making a search for a customer who wanted to know what had been published about barn owls since the 1880's, the Berkeley staff used the computer data bases to find out about newer materials, but had to look up the older publications by hand.



The WESTFORNET staff will answer general reference questions, either by phone or by mail.

Other services offered

"General reference questions"—a staple in any librarian's diet—are also on the WESTFORNET menu. People use WESTFORNET's telephone "hot-lines" to get statistics about places and products, or to confirm the titles of books or articles. All the WESTFORNET centers are well-stocked with an array of directories and other reference books.

When someone needs information about a problem that doesn't seem to be mentioned in any written materials, WESTFORNET will try to locate specialists who are doing research on the subject, and will put their customers in touch with the researchers. A person who needed information about the plants of southern California's Santa Ana mountains, for example, was directed to a researcher at the San Diego Museum of Natural History and to a professor at the University of California at Los Angeles, both of whom were doing work on the topic.

Currently, WESTFORNET-Berkeley and Seattle each send out about 200 documents a day and answer some 30 reference calls—levels that the Ogden and Fort Collins centers are expected to soon reach. In 95 percent of the cases, customers can get the documents they want—although there may be a wait for some of the more popular or more obscure items.

The WESTFORNET staff has found that once people try out WESTFORNET, and are satisfied with the service they get, they often come back for more help, and frequently want to use more than just one type of WESTFORNET service. The staff plans to publish a detailed guide to the services; a slide show, designed for new users, was released last summer.

"We're trying to help people cope with the huge and continuing growth of scientific information," says WESTFORNET coordinator Bruce Yerke. "We hope to be able to offer WESTFORNET to more government and private organizations later on. WESTFORNET is something that the Forest Service has, and everyone wants."

—By Marcia Wood, Pacific Southwest Station

Healing the wounded tundra

In a nation of mushrooming populations and dwindling resources, the alpine tundra of the western United States beckons like a promised land. The alpine ecosystems are surrendering their solitude and silence to road construction, recreational vehicles, livestock grazing, and mining activities.

The alpine tundra is not a land for soft living—its environments are among the most rigorous in the world. Whipping winds blow the winter's heavy snows from lofty, exposed ridges into deep pockets on protected slopes. There the snow creates formidable drifts that linger into summer, delaying the growing season.

Low-growing herbs, dwarf shrubs, lichens, and mosses—some of them relics of colder times—cling to rocks and sterile, shallow soils. Subjected to frost damage and abrasion by windblown ice and soil particles, plant growth is sparse.

Alpine ecosystems, long recognized for wildlife habitat, recreation, and livestock range values, probably serve their most vital role as watersheds. Heavy snow accumulation is an important source of late-summer streamflow.

Today, many alpine areas are threatened with severe disruption by man. The nation's search for minerals has thrust these lands into the limelight. Of the approximately 7.4 million acres of alpine tundra in the western United States, almost 12 percent have been severely disturbed and require rehabilitation.

Surface mining and associated roads at high elevations result in extensive disturbance to vegetation, soil, and water resources.



Perhaps the most severe problems occur when soils and water of these areas become acid as a result of mining activities. The contaminated runoff destroys down-slope plant communities and degrades water quality and aquatic ecosystems.

Rehabilitation methods that have been successful in moderate life zones don't work in the severe environment of the alpine tundra. Special techniques are necessary to accommodate the short, cool growing seasons, uneven snow distribution, and frost action.

Since 1972, researchers at the Intermountain Station's Forestry Sciences Laboratory, Logan, Utah, have been working to develop rehabilitation techniques for these unusual lands. Studies have included several different aspects of rehabilitation such as plant succession, species adaptability, and differences in microenvironments.

An example

In 1976, the scientists found an ideal site to apply the techniques on a large scale—the inactive McLaren Mine in the Bear-tooth Mountains of Montana. The 33-acre, open-pit mine is located high (9,800 ft) on a slope in the headwaters of the Stillwater River. Acidic water containing toxic concentrations of heavy metals had drained onto and contaminated adjacent plant communities and aquatic habitat.

Ray W. Brown, plant physiologist, and Robert Johnston, research hydrologist, both of the Logan Forestry Sciences Laboratory, are leaders of the group working specifically in alpine environments. Brown says, "The McLaren Mine site was made to order. There, we could see if our techniques would establish stable plant cover on the sterile, acid, mine spoils."

Early results indicate the McLaren project has been a success. And a major objective was achieved—to demonstrate that the results of small-plot studies and greenhouse bioassays can be applied in large rehabilitation programs.

The principles of rehabilitation for alpine tundra disturbances have been brought together and are discussed in an article published in the July-August 1978, issue of the *Journal of Soil and Water Conservation*, "Rehabilitation of Alpine Tundra Disturbances," (INT-R-FR17). Authors are Brown, Johnston, and Douglas A. Johnson, plant physiologist, Science and Education Administration, Crops Research Laboratory, Utah State University, Logan.

General considerations

The authors say that although rehabilitation may be undertaken for several reasons, the primary objectives are to restore surface stability, esthetic appeal, and perhaps productivity. In most cases, establishment of plant cover is recognized as the primary means of achieving rehabilitation.

Native plants adapt to the harsh conditions of the tundra and compete successfully for scarce water and nutrients. These plants have several common qualities—low-growth form, drought resistance, low mineral nutrition requirements, and vigorous sexual and vegetative reproductive capabilities. However, experience has shown that even though a native plant thrives in an undisturbed tundra environment, it may not do well in a rehabilitation venture. Disturbances change the picture completely. In a study conducted on the Beartooth Plateau of Montana, Brown and Johnston determined that only about 10 percent of the native plants were successful on rehabilitated alpine disturbances. They concluded that the best plant materials for revegetating these lands are the few adapted native species that naturally colonize disturbed sites.

Recommendations

Brown and others offer specific recommendations for land managers faced with rehabilitating alpine disturbances. Some key considerations are:

Contouring and Shaping—Disturbed areas should be reshaped to conform as nearly as possible to the original land contour. Although topsoil is almost nonexistent in some alpine environments, the medium that produced vegetation before the disturbance should be stored separately for later use in the rehabilitation effort.

Revegetation — Use only those plants that are adapted. Brown and the others have identified 34 grasses, forbs, and woody species that have been used successfully. Only one species, meadow foxtail (*Alopecurus pratensis*), is commercially available at this time. Seed for the other species must be collected by hand, but this situation should improve. The Forest Service and the Soil Conservation Service have embarked on a cooperative program to produce seed under nursery conditions. Also, seed is currently being collected from most of the adapted native grasses identified by the researchers.

Select the proper time for seeding and transplanting. Studies indicate late fall is best, ensuring that plants will begin growth during the spring, when conditions are most favorable.

Fertilizer is essential for plant growth and development. Application rates and relative ratios of vital nutrients vary on different sites and should be determined by soil analyses. Lime, superphosphates, and manure are some of the fertilizers used in greenhouse and field studies. Organic matter, such as peat moss and straw, worked into the surface soil improves plant growth and the capacity of the soil to hold nutrients and water. When ready to plant, use mixtures of seed containing several species to lessen the chance of failure.

Transplanting whole plants that are dormant can be combined successfully with seeding. Transplants have high survival rates and provide an almost immediate seed source on disturbed alpine areas. However, transplanting involves more labor, which makes it expensive. The authors suggest reserving this method for small, critical areas.

Protect the seeded or transplanted areas. An insulated surface mulch—straw or jute netting—will counteract frost action and evaporation of surface soil water.

Postplanting Management is crucial to success. The authors say livestock grazing and recreational travel should be restricted for at least five growing seasons to permit adequate plant establishment. Other studies have estimated the rate of recovery of untreated alpine disturbances at several hundred to one thousand years.

In the face of expanding development, the major need is not to withdraw sensitive alpine lands from reasonable use, but to develop the technology and skills necessary to return them to a self-sustaining condition. The researchers are confident that this can be done, and look forward to helping land managers make rehabilitation a reality.

If you would like information on other studies conducted on this subject, you might want to read:

Brown, R. W., R. S. Johnston, and K. VanCleve. 1978. Rehabilitation problems in alpine and arctic regions. *In*: Reclamation of Drastically Disturbed Lands. Am. Soc. Agron., Madison, Wis., pp. 23-44. pp. 23-44.

The alpine tundra research effort is funded by the SEAM program. SEAM, an acronym for Surface and Environment and Mining, is a Forest Service program to research, develop, and apply technology that will help maintain a quality environment and other surface values while helping meet the Nation's mineral requirements. SEAM is a partnership with land managers, regional planners, mining industries, and political jurisdictions at all levels.

—by Delpha Noble, Intermountain Station

Contouring and shaping are essential to provide optimum conditions for revegetation.



Applying straw mulch during revegetation of an alpine disturbance in Montana.



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Everything about growing container seedlings

Growing containerized seedlings in a controlled environment greenhouse can produce healthy, fast-growing planting stock.



The demand for forest tree planting stock can be met in several ways. One of the newest and most popular and successful is in a containerized seedling tree nursery. In such a nursery, seedlings are reared in a growing medium placed in a container specially designed for this purpose. The containers are usually kept in a greenhouse where the growing environment is controlled.

"Container nurseries" are superior to conventional "bare root nurseries" in several ways: They can be established on land with low agricultural value; water quality is not as crucial; greenhouse-grown trees are not exposed to weather, so production is more reliable; containerized seedlings are less perishable during transit to the planting site; disease and insect problems are more easily controlled in a greenhouse; and containerized seedlings generally grow faster than bare root stock.

If you find yourself in a position where you are considering starting a containerized seedling greenhouse nursery, there are a few points to consider: What types of greenhouses are available? What kind would best suit your needs? Who will manage it? What will it cost? Where's the best place to locate it? What about cooling and heating, watering and fertilizing, carbon dioxide control, humidity, lighting, operating equipment, manpower? HOLD IT! What you need first is a good reliable source of information.

A new "how to" manual, due off the press in January or February of this year, should provide the greenhouse nurseryman with comprehensive data on starting a containerized tree seedling nursery and the science and art of growing trees in containers. "How to Grow Trees in Containers in Greenhouses", by Research Plant Physiologist Dick Tinus, Rocky Mountain Station, and Stephen E. McDonald, Nursery and Greenhouse Specialist with the Forest Service's Rocky Mountain Region, has been in the making since 1975. Information was collected from not only a myriad of published material, but from personal interactions with authorities on the subject. The authors have included answers to some of the most asked questions by administrators and nurserymen on greenhouse nursery techniques.

The manual is structured to provide the reader with two things: (1) a general reference regarding greenhouse nursery development, with advice on greenhouse development, economics, hardware and containers for growing seedlings; and (2) a specific reference for the art and science of growing containerized forest tree seedlings. Although the focus of the material is on greenhouse development in the western United States, much of the information can apply to other parts of the country as well.

Tinus says, "although it provides an enormous amount of information, the quality of that information about seedling biology can vary considerably. Therefore, a three-level grading system is used throughout the publication to inform the reader of how much confidence can be placed in what is said." For example: "Level A" - this information has been developed in controlled experiments and thoroughly tested in production greenhouse situations. It is known to be complete and accurate. "Level B" - this information has been developed in small scale experiments or results from accumulated experience in production greenhouses. It is believed to be valid, but is subject to further testing. "Level C" - this information is based on observation and frequently isolated cases. It is offered in the spirit that some knowledge is better than none.

Orderly Sequence

The manual is arranged to provide an orderly sequence of information, from planning your nursery, to delivering seedlings to planting sites. The vast selection of topics covered include: requisites and economics of greenhouse development, component parts, including hardware and instrumentation; greenhouse temperature, lighting, water systems, humidity, and carbon dioxide control; growing schedules; seed and sowing; a comprehensive section on growing the seedlings; keeping records; greenhouse management and supervision; pest management, plus a unique unit on troubleshooting nursery problems.

"How to Grow Trees in Containers in Greenhouses" is an invaluable and indispensable source of information for not only those considering starting a containerized seedling operation, but for the established nurseryman as well. If you have a question about growing containerized seedlings in greenhouses, chances are this manual holds the answer.

The publication is available from the Rocky Mountain Station. Write for your copy and request General Technical Report RM-60-FR17

—by Rick Fletcher, Rocky Mountain Station

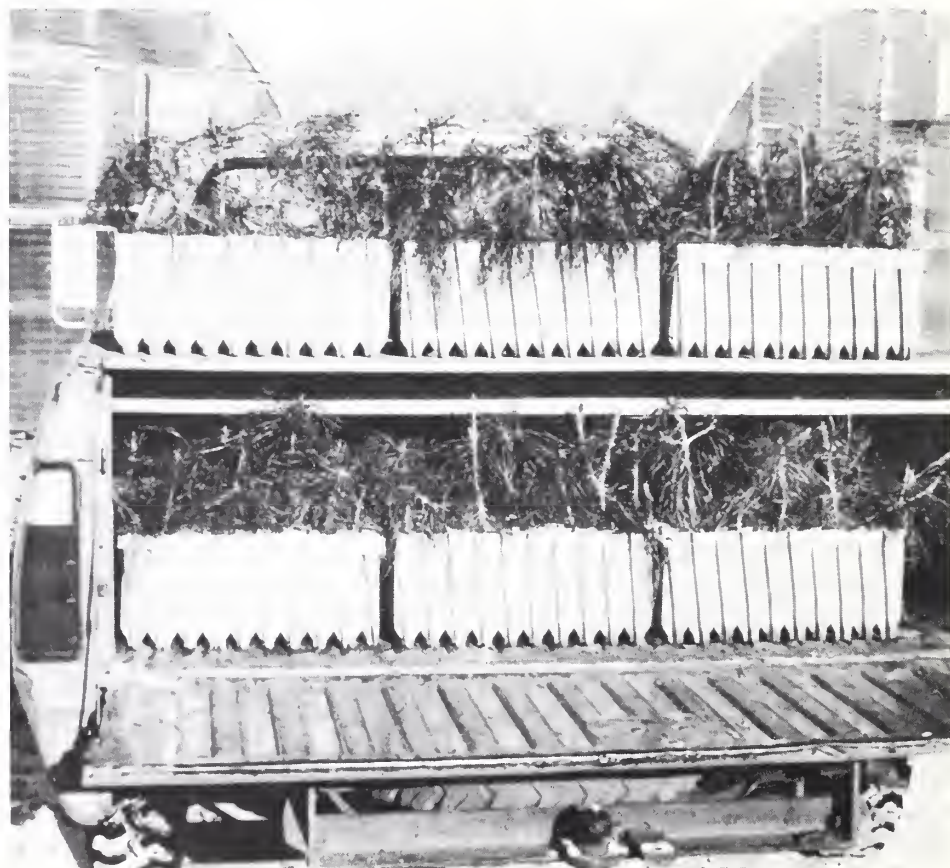


An environmental control panel keeps check on temperature and humidity levels, along with automated lighting and watering systems.



Dick Tinus examines 6-month-old siberian larch seedlings.

Transplanting containerized seedlings



Publications

Don't bury it—use it!

Flyash deserves a better fate than being disposed of in landfills. A recent study suggests that the solid ash produced by forest products boiler plants can be used as a fertilizer and soil amendment.

The Intermountain Station has published the results of an analysis of flyash from four bark-fired boiler plants in the Missoula, Montana area. John R. Host of the Station's Forestry Sciences Laboratory, Missoula, and Roger Pfenninger, now with the Intergovernmental Council, Seaside, Oregon, conducted the study.

Host and Pfenninger analyzed flyash samples from different sources in each of the four boiler plants. Responses showed the material could serve as a fertilizer or soil amendment, and can be added to pulverized bark to improve heavy clay soils. Although flyash nutrient is low, its natural timed release provides nutrients over an extended period. Preliminary field tests show that growth response is evident 3 years after application.

The flyash study is part of the Station's effort directed toward increasing utilization and product alternatives from forest and processing plant residues.

For more information on this subject, write to the Intermountain Station for a copy of "Plant Nutrients in Flyash from Bark-Fired Boilers," INT-RN-247-FR17, by Host and Pfenninger.

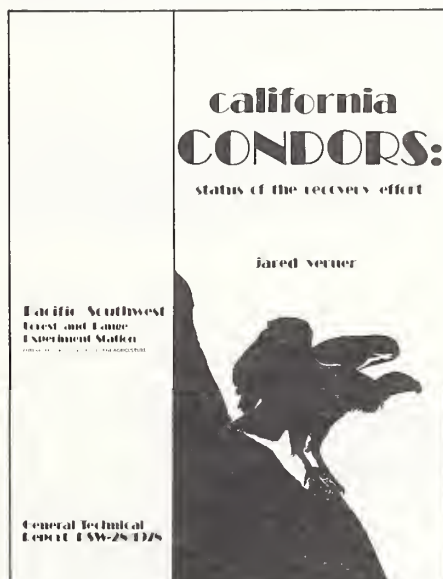
Helping the California condor

Among North American birds, the California condor is "one of those that are the most threatened with extinction," according to wildlife biologist Jared Verner of the Pacific Southwest Station. Verner's analysis of the plight of this species is contained in a report from the PSW Station, "California Condors: Status of the Recovery Effort", General Technical Report PSW-28-FR17.

The southern California population of some 40-50 condors is all that remains of a species that once ranged from Baja California to Basin Columbia. "The problem with the condors right now is that they are not reproducing successfully," Verner says. "In order to maintain a population of at least 50 condors, the adult birds need to make a minimum of 8 nesting attempts each year, and from this, at least 5 or 6 healthy fledglings need to be reared. But, very few adults are even attempting to nest, and we don't know why." Among the possible reasons are inadequate supplies of food near nests, lack of suitable nesting sites, and accumulation of pesticides in condor tissues.

- provide funds needed for year-around monitoring of the birds;
- provide condors with more nest sites, by creating caves in existing or man-made cliffs;
- analyze the foods that are important in the condor diet, including the carcasses of such animals as deer, cattle, sheep, horses, goats, rabbits, and ground squirrels, to determine if they contain pesticides or other poisons;
- take air samples in the condor range, to see if harmful levels of pollutants are present.

Verner's reasons for making each of these recommendations are in the Report; copies are available from the PSW Station.



Verner strongly supports the controversial plan to raise condors in captivity, and points to the success of both the U.S. Fish and Wildlife Service and the San Diego Zoo in captive rearing of the Andean condor, a close relative of the California condor. His other recommendations include:

- analyze the past and present vegetation structure in the condor's range, to detect any significant changes in the size of meadows and other open spaces condors use when feeding;
- develop a safe, effective technique, such as tattooing the condors or outfitting them with radio transmitters, to monitor condor movements and numbers accurately;
- standardize the procedures that are used in the annual condor count;

Seed production and dispersal in clearcuts.

The climax spruce-fir forests of the central Rocky Mountains grow in harsh environments, where natural regeneration is difficult to establish. Although there has been considerable regeneration research in these forests, many reforestation questions remain unanswered.

A new research paper titled "Seedfall and Establishment of Engelmann Spruce and Subalpine Fir in Clearcut Openings in Colorado," by Daniel L. Noble and Frank Ronco, Jr., helps clear up some of the questions. The paper reports on a study conducted between 1961 and 1975 on clearcut openings at five locations in the spruce-fir zone of Colorado. Researchers report that seed availability generally does not limit regeneration success, but that seedbed and other environmental conditions are limiting factors. Stocking appears dependent on the size of clearcut openings, which should not exceed 8 chains (approximately 500 feet) in width. Results also indicate that seedlings surviving to 4 years of age have a good chance of establishment.

If you would like additional information on the amount and frequency of seed crops, seed dispersal in relation to distance from source, and initial stocking of seedlings in clearcut openings, write the Rocky Mountain Station and request Research Paper RM-200-FR17.

The case of the recovered forest

"Stand damage caused by outbreaks of the Douglas-fir tussock moth may not be as severe over the long term as previously thought," says Boyd Wickman, insect ecologist at the Pacific Northwest Station, in a report of the first study to measure the recovery of a forest from a defoliating insect outbreak.

The report describes what happened in the ten years following a small but typical outbreak of the insect in northern California. The outbreak occurred in 1964 in a predominantly white fir stand which had replaced most of the original pine after logging around 1900. No fire had occurred in the stand for at least 50 years. Stand conditions before the outbreak were compared with growth and mortality two years after the outbreak and ten years later.

Growth of the defoliated fir was depressed during and immediately after the outbreak, but subsequent growth was greater than pre-outbreak levels. After ten years the number of fir seedlings less than ten years old was the same as before the outbreak, and there was more advanced reproduction in 1975 than before the outbreak.

Wickman also discusses several patterns he has observed in studies of other outbreaks over the past 22 years, which were confirmed by the California outbreak. Mortality is related to the intensity of defoliation. Mortality tends to be severe in concentrated patches, but the total area of these patches is relatively small, usually 10 to 14 percent of the outbreak area. The effect of scattered mortality caused by tussock moth outbreaks is similar to thinning. Growth over a rotation is probably enhanced because of reduced competition among the surviving trees.

In California, most outbreaks tend to occur in second-growth fir stands, often in association with pine. Wickman suggests that the practices of harvesting overstory pine and excluding fire for the past 75 years have created susceptible host stands of white fir on pine sites. This relationship probably holds true for other stands in the west as well.

Outbreaks are also influenced by relationships developed over the thousands of years of co-evolution between insect and host. These include the response of the defoliating insect to changes in foliage condition caused by fluctuations in soil moisture, pollution and other stresses, and changes in the number of natural enemies caused by habitat modifications. Although these relationships are not yet well understood, it is possible that the tussock moth plays a natural role as a system regulator and in the long term this role is beneficial.

Wickman suggests that the real payoff in research will come from long-term studies of the response of forests to outbreaks and of the role of insects. A report of another similar study will be published soon.

Copies of "A Case Study of a Douglas-fir Tussock Moth Outbreak and Stand Conditions 10 Years Later," by Boyd E. Wickman, Research Paper PNW-244, are available from the Pacific Northwest Station.

New use for old technique

The line-intersect method, commonly used to inventory logging residues, can be adapted to estimate cordwood in single-leaf pinyon and Utah juniper. A report published by the Intermountain Station discusses how researchers used the method to inventory pinyon and juniper cordwood in Nevada.

Authors Richard O. Meeuwig, Elwood L. Miller, and Jerry Budy explain the field application and review the mathematical basis in "Estimating Pinyon-Juniper Cordwood with the Line-Intersect Method," INT-RN-242-FR17. Meeuwig is Project Leader of the Station's research work unit concerned with ecology and management of pinyon-juniper woodlands and associated shrublands in the Great Basin. Miller and Budy are on the staff of the Max C. Fleischmann College of Agriculture, University of Nevada Reno.

The line-intersect method, a procedure for sampling with probability proportional to size (p.p.s.), is particularly suited for inventorying woodland trees. It provides a relatively simple way to apply p.p.s. sampling to trees that have irregular (sometimes multiple) stems, and branches all the way to the ground.

The method was also adapted in 1971 by James K. Brown, research forester at the Station's Northern Forest Fire Laboratory, Missoula, to sample fuel volume and surface area.

If you would like more information on the Nevada study, write to the Intermountain Station for a copy of the report.

Dead log lumber needs different treatment

Operators of sawmills that produce a substantial quantity of dead log lumber can reduce energy costs by shortening kiln drying time by at least 50 percent. Avoiding excessive drying will also prevent degrading the lumber.

This information is included in an Intermountain Station report, "Moisture Content of Lumber Produced from Dead Western White Pine and Lodgepole Pine Trees," INT-RP-212-FR17. Authors are David P. Lowery, wood technologist at the Station's Forestry Sciences Laboratory, Missoula; and Allen L. Hearst, Jr., utilization specialist with State and Private Forestry, Northern Region, Missoula.

Lowery and Hearst conducted the study to determine the moisture content, before drying, of lumber made from dead white pine and lodgepole pine logs. Each of the species was processed at a single mill. Lowery and Hearst used both a moisture meter and the standard oven-dry test. They then compared the results to determine accuracy and consistency between the two methods. The moisture content of lumber from dead western white pine and lodgepole pine trees is about half that of lumber cut from green trees.

According to the authors, variability in trees from different areas, and in milling equipment and procedures prevents hard and fast rules for drying lumber from dead trees. If only an occasional dead log is milled, the present practice of mixing the dead with green lumber and using the green lumber drying schedule is satisfactory. However, if enough dead timber is produced to justify sorting and a special drying schedule, greater efficiency will result.

For details on this study, write to the Inter-mountain Station for a copy of the publication.

Visitors not "hooked" on fishing

Forest managers may be surprised to learn that catching fish is not particularly important to people who visit backcountry and wilderness areas. Researchers from the Pacific Northwest Station reached this conclusion after an exploratory study of the role of fishing in the recreation experience of visitors to seven high mountain lakes in Washington.

Fishing and catching fish are only one part of the backcountry experience, researchers found. Less than 20 percent of the visitors were ardent fishermen. Almost 60 percent of the visitors did not fish, and 40 percent of the parties had no fisherman. Among the visitors who did fish, 80 percent gave higher priority to other motives for visiting the lake. These included enjoyment of nature and scenery, relaxation, escape from daily routine, and companionship. Most visitors came in groups. They spent 80 percent of their time at their camps or at the lake shore. If possible, they set up camp along the shore or in view of the lake.

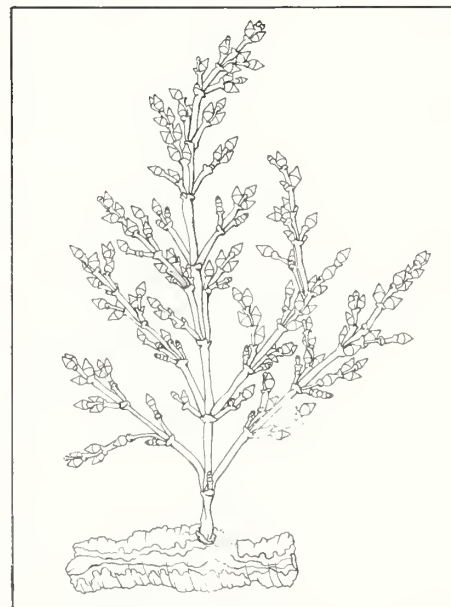
A factor far more likely to affect visitor use than the supply of fish was the effort required to reach a particular destination. Trail distance, condition, and elevation gain were major considerations. The researchers recommend that managers make both fishermen and nonfishermen aware of the recreation opportunities available and the effort required to reach each destination so visitors can choose the type of experience they want.

Results of the study are reported in "Fishing and Other Recreation Behavior at High Mountain Lakes in Washington State" (Research Note PNW-304) by John C. Hendee, Roger N. Clark, and Thomas E. Dailey, available from the Pacific Northwest Station.

Update on dwarf mistletoe control

Information and advice on how to control dwarf mistletoe—the most destructive disease agent in Western U.S. forests—is presented in a 190-page report from the Pacific Southwest Station. The publication, "Proceedings of the Symposium on Dwarf Mistletoe Control Through Forest Management," contains 30 papers that were presented to an audience of more than 250 foresters and researchers at the Symposium, which was held last spring in Berkeley, California.

The volume covers the life cycle, spread, impact, and control of the parasite, explains ways to inventory mistletoe damage, and stresses the need to coordinate mistletoe control activities with other pest management and silvicultural measures. Among the authors are forest managers from British Columbia, Washington, Oregon, California, Colorado, and New Mexico, who describe strategies they have used to control local infestations of mistletoe. Papers written by researchers who are foremost authorities on dwarf mistletoe are also presented. Copies of the Proceedings, which have been issued as General Technical Report PSW-31-FR17, are available from the Publications Section, PSW-Berkeley.



Hemlock dwarf mistletoe is one of the more than 20 different species of dwarf mistletoe that occur in the U.S.

Watch for the April issue. It will feature articles on: managing high alpine spruce-fir forests; fuel science; and much more. Don't miss it!

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